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APPLICATION OF ERTS-1 IMAGERY TO DETECTING AND MAPPING MODERN
EROSION FEATURES, AND TO MONITORING EROSIONAL CHANGES,
IN SOUTHERN ARIZONA¹

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Type II Progress Report

ERTS-1

- a. Title: Application of ERTS-1 imagery to detecting and mapping modern erosion features, and to monitoring erosional changes, in southern Arizona.

ERTS-A Proposal No. SR 182

- b. GSFC ID No. of P.I.: IN 050

- c. Problems encountered:

A processing problem has been corrected -- the Newton rings that commonly were present in the earlier images received and constituted objectionable "noise".

All bands of the images taken last summer were over-exposed in the desert areas because of the high reflectance of the light-toned desert soils. Inasmuch as the deserts are very important parts of our study area, this over-exposure seriously hampered our interpretive efforts. It resulted in less contrast and detectability of the features for which we are looking. The late fall and winter images are correctly exposed for the desert areas because the lower sun-elevation angle has reduced the total spectral response.

The delay in receipt of images also considerably hampered the investigation. Many of the better images were not received until near the end of the reporting period and therefore have not yet been fully evaluated. Only 70mm positive transparencies will be much more advantageous for interpretation.

In addition, atmospheric haze (mainly smog and smelter smoke haze) appreciably degrades many of the images, especially in the lower parts of the intermontane basins and near Phoenix and Tucson.

- d. Accomplishments during the reporting period:

Examination procedure

Upon receipt, each 70mm image is given preliminary examination under 10X magnification, indexed, and evaluated in terms of coverage of the study area, cloud cover, contrast, resolution, atmospheric degradation, other defects, and also the post-1890 erosion phenomena and other pertinent features displayed. Although the first 70mm images arrived Sept. 28, by the end of the reporting period good coverage of the entire 17,000 sq. mi. study area was available. We received one 9" x 9" 1:1 million scale positive transparency from the Sioux Falls Data Center. In addition, we ourselves prepared negative enlargement prints at about 1:1 million scale from the 70mm positive transparencies.

Indexes also are prepared for all U-2 airphotos received.

We tried projecting the 70mm transparencies onto a screen with a lantern-slide projector, and also projecting the 9" x 9" transparency with an overhead projector. However, it was found most convenient to view the 70mm images under a binocular microscope. Compared with lantern-slide projection, the images are

not liable to deterioration from excessive heat, and excessive glare in the over-exposed areas can be reduced more easily. Nine times magnification proved to be best for general purpose scanning and for identifying geologic features; this enlarges the images to about 1:1/3 million scale. In places higher magnifications were used for discriminating local details. In order to reduce glare and increase contrast in the brightest areas, the intensity of the light source was varied and colored Diazochrome sheets (Key Cyan, Kor Orange, and Pastel Brown were most useful) were inserted between the light source and the image.

We have ordered from the Sioux Falls Data Center 1:250,000-scale enlarged prints of good-quality ERTS images covering the entire study area, as well as 9" x 9" positive transparencies of the better images. We believe the most efficient and productive interpretive mapping procedure will be to view 9" x 9" transparencies under a zoom transferscope and plot our interpretations directly onto either Army Map Service 1° x 2° maps or onto the 1:250,000 enlargements of the ERTS images.

The seven-phase interpretation program

In this project, a 7-phase program of interpretation of ERTS-1 data is being used.

Phase 1 consists of preliminary mapping of the post-1890 erosion phenomena and other data relevant to the erosion problem (such as the more erodible soils) using only the ERTS-1 imagery.

Phase 2 consists of photo-interpretive mapping of the modern erosion phenomena and other features relevant to the erosion problem from U-2 and RB-57 ultrahigh aerial photographs, in selected parts of the whole study area.

Phase 3 involves compilation of available published and unpublished ground truth data (hydrologic, geomorphic, geologic, soil, etc.) on maps of suitable scales, without using ERTS data.

Phase 4 is a comparison of phase 1, 2, and 3 products, with additional photointerpretation, to prepare "enhanced information maps", noting any differences and anomalies.

Phase 5 consists of additional analysis made from repetitive ERTS and ultrahigh airphoto coverage of the study area, noting any detectible erosional changes, such as widening, deepening, aggradation, or headward growth of gullies and arroyos, and also any added information (at least the differences in information content) on the features we are mapping resulting from time-variant phenomena such as changes in vegetation, soil moisture, and sun-elevation angle.

Phase 6 consists of appropriate field studies to obtain necessary ground-truth data, particularly to evaluate interesting features found in earlier phases.

Phase 7 is the delineation of any new information detected from the ERTS and ultrahigh airphoto data.

The investigation is expected to progress in regular sequence through the lower phases, but because the study area is very large and because detailed studies of parts of it will be undertaken at differing rates, later in the program the investigation is expected to be in different phases at the same time. At the end of this reporting period, phase 1 had been largely completed and the investigation was in phases 2 through 5 in various parts of the study area.

General interpretation information

Figure 1 gives the results of phase 1 of the study. It shows all the arroyos within the study area that have been identified from the ERTS images received to date. We find that the "red" MSS band 5 gives the sharpest definition of modern arroyos. As linear features, the arroyos can be distinguished where their width is about a tenth as wide as the minimum width for recognition of equidimensional features. On the best images, we can distinguish arroyos as narrow as 150 to 200 feet in reaches where their contrast with adjacent areas is only moderate, and as narrow as 60 to 75 feet in reaches where their contrast is high. High contrast is produced by dark riparian vegetation against light-toned arroyo beds and soils of former flood plains that now are bare of vegetation.

We also are in process of mapping the areas of the more erodible soils that can be differentiated from the ERTS images. Both the red and infrared bands (bands 5, 6, and 7) shows differences in soils and vegetation. In the late-fall and winter imagery, band 7 generally is the more useful for mapping the more erodible soils.

Figure 2 is an example of the more detailed mapping possible with the ultrahigh airphotos. We used 9 1/2" x 9 1/2" color infrared positive transparencies (EK 2443 film), taken August 1, 1972 by NASA's U-2 aircraft with a Wild RC 10 metric aerial camera at about 62,500 feet above ground, giving a photo scale of about 1:125,000. We are extremely pleased with the resolution-detectability and spectral-sensitivity characteristics of these photographs, and we feel that they will be of great value to this investigation. The map shows a belt along San Simon Wash between the towns of San Simon and Solomon, that has been affected considerably by post-1890 erosion. This wash is 75 miles long and has a drainage area of about 2,200 square miles. It has trenched its channel commonly 20 feet and in places 40 feet since 1905. The solid black lines show the channels and narrow flood plains that have formed since 1905, and the three types of patterns show the areas that are severely gullied, severely sheet-eroded, and moderately sheet-eroded. We plan to prepare similar maps for sizeable parts of the study area, that represent all the important soil, climatic, vegetational, and geomorphic-topographic conditions, and also the areas most affected by post-1890 erosion.

The ERTS images also show two important effects of a large flood in the study area -- the extent of inundation and the areas affected by severe sediment deposition and erosion -- although the images were made a week and a half after the flood. On October 20 and 21 the upper Gila River had its third-largest flood on record. Peak flows attained about 42,000 and 82,000 cubic feet a second at Duncan and Safford, Arizona, respectively. Two lives were lost (in New Mexico), and hundreds of people made temporarily homeless, and more than 10,000 acres of cropland were inundated.

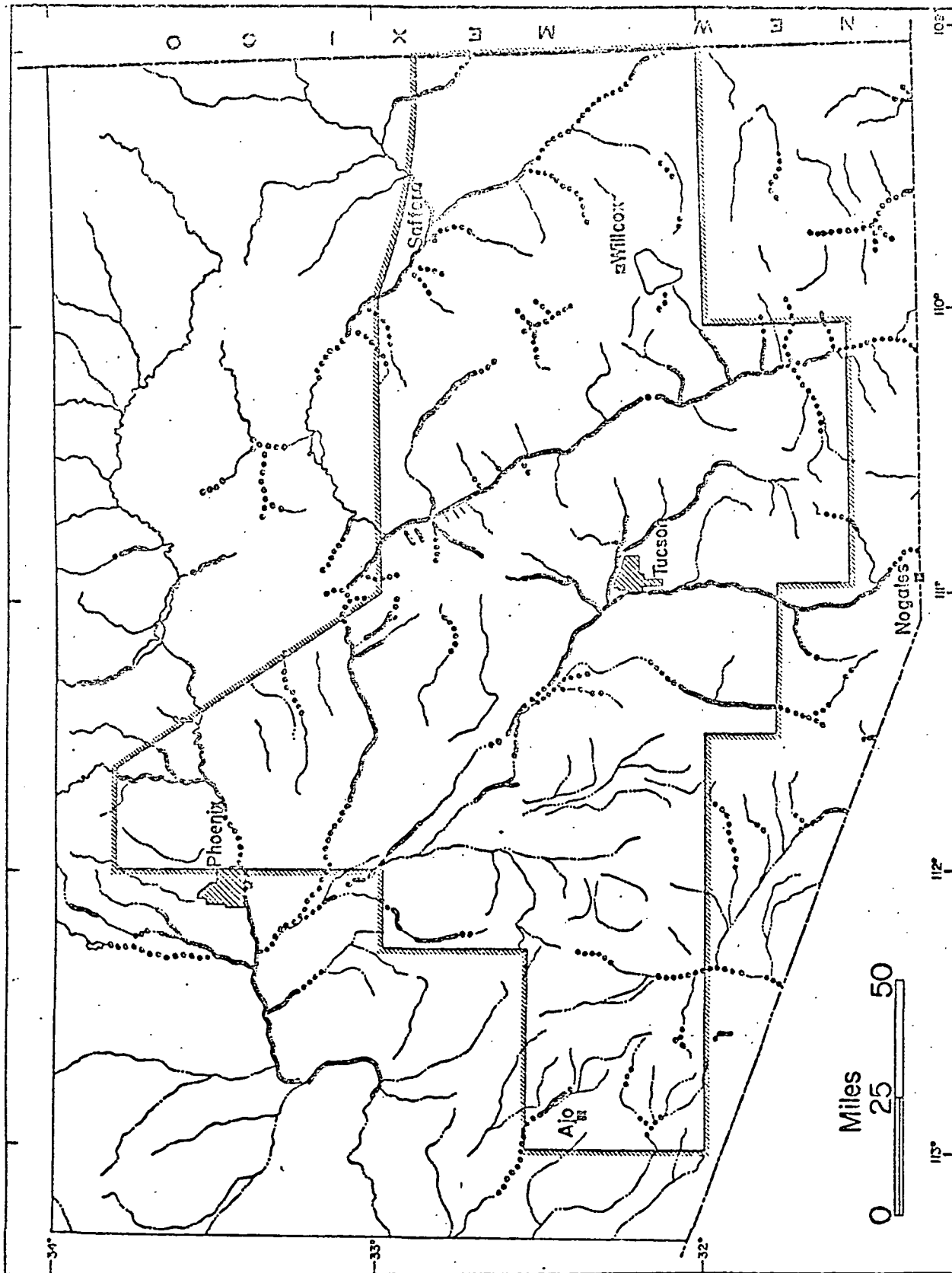






Figure 1. Modern arroyos in south central and southeastern Arizona that are detectable from ERTS-1 imagery (shown as heavy lines where continuously detectable, dotted lines where intermittently detectable).

-  Stream channels and flood plains
-  Severely gullied
-  Severely sheet-eroded
-  Moderately sheet-eroded

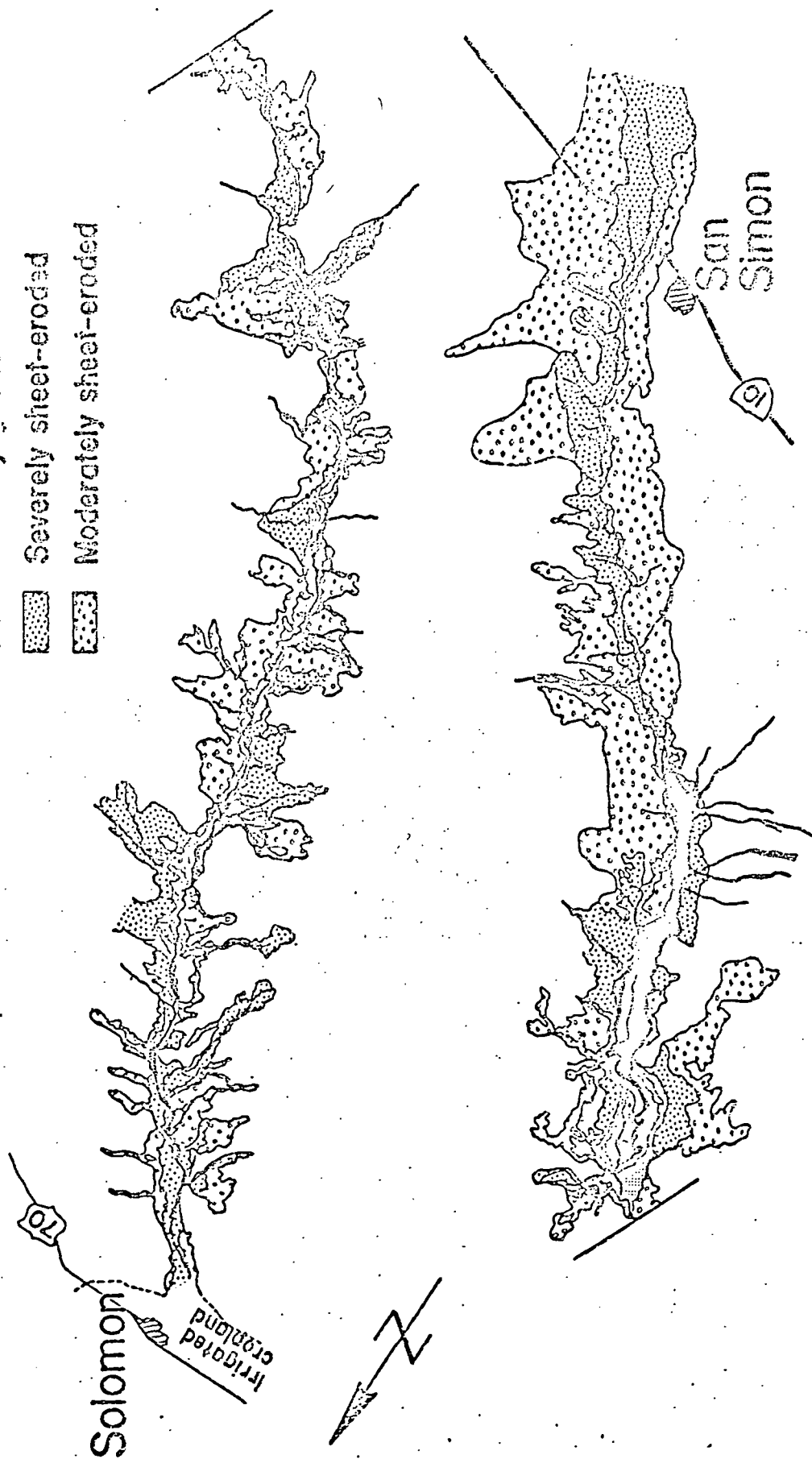


Figure 2. Map of modern erosion features along a 50-mile reach of San Simon Wash.

The first ERTS images after the flood were made Nov. 1 and 2. The inundated area is best displayed on the infrared bands, particularly on band 7, where it appears as a belt that is distinctly darker than adjoining parts of the flood plain. This dark belt does not appear on ERTS images that pre-date the flood; it had almost disappeared in images made Nov. 19, and entirely in December images. Probably the low infrared reflectance of this belt is caused by still-moist soil and by flood-stressed vegetation. Inundation limits mapped from band 7 of the Nov. 1 2 frame agree well with those obtained from aerial photographs that were taken during the flood (Fig. 3). Areas of severe sand and gravel deposition and erosion show best on band 5, as anomalously light-toned areas compared with earlier images. By comparing before-and-after images in this band, a quick assessment can be made of the severely flood-ravaged land.

Plans for next reporting period:

1) If better images are received than those available during the present reporting period, update the map (Fig. 2) showing the arroyos detectable from ERTS images.

2) Complete the map showing the distribution of the more erodible soils that can be detected from ERTS images.

3) Prepare the U-2 and RB-57 airphotos larger-scale maps of selected parts of the whole study area, showing the various post-1890 erosion phenomena in detail and other features relevant to the erosion problem (such as the more erodible soils and vegetative ground-cover (especially grass/forb cover)) conditions.

4) Start field studies to obtain ground control for 2 and 3.

5) From the repetitive ERTS images and ultrahigh airphotos, monitor current erosion changes (particularly after heavy rains and big floods), including the erosional effects of highway construction, stream channelization, and urban and suburban developments.

6) Utilize previous aerial photography (which dates back to 1935) to prepare detailed maps showing the status of post-1890 erosion in selected areas at various dates. From this and data from 5, determine the rates of various aspects of the post-1890 erosion, such as the rates of widening, deepening, aggradation, and headward growth of arroyos and gullies.

7) Using a zoom transferscope and ERTS imagery, map at 1:250,000 scale the areas of inundation and of severe sand/gravel deposition/erosion in the Gila (Safford) Valley that resulted from the Oct. 20-21 flood on the Gila River.

8) Using computerized electronic enhancement of one or more selected ERTS images, such as that done by the Jet Propulsion Laboratory, Pasadena, compare the results from interpretation of the enhanced imagery with that from unenhanced ERTS images.

e. Significant results and their practical applications:

This project is testing the applicability of ERTS-1 imagery to detecting and mapping erosion features that have resulted from the modern episode of accelerated erosion in southern Arizona -- arroyos, gullies, and sheet- and wind-eroded areas that have developed since 1890. The area of study comprises

FLOOD LIMITS FROM AERIAL PHOTOGRAPHY DURING FLOOD



FLOOD LIMITS FROM ERTS IMAGERY 1 1/2 WEEKS AFTER FLOOD



Severe sediment deposition/erosion



Figure 3. Limits of the October 20 and 21 flood on the upper Gila River in the Safford (Gila) Valley, Arizona, as determined from low-altitude aerial photography taken during the flood and from ERTS-1 imagery taken 1 1/2 weeks after the flood.

17,000 square miles. To provide a basis for comparison with the results obtained from the ERTS images, U-2 and RB-57 ultrahigh airphotos also are used for larger-scale photo-interpretive mapping of the modern erosion phenomena and other features relevant to the erosion problem. Current erosion changes (from heavy rains and big floods) also are being monitored with the ERTS imagery and ultrahigh airphotos.

We find that the "red" MSS band 5 gives the sharpest definition of modern arroyos. On the best images, we can distinguish modern arroyos as narrow as 150 to 200 feet in reaches where their contrast with adjacent areas is only moderate, and as narrow as 60 to 75 feet where their contrast is high. Both the red and infrared bands show differences in soils and vegetation. In the late fall and winter imagery, band 7 generally is the most useful for mapping the areas of the more erodible soils.

A map at 1:1 million scale has been prepared that shows all the arroyos within the study area that have been identified from the ERTS images. Also, from U-2 color-infrared airphotos, a 1:125,000-scale map has been made of a 50-mile reach along San Simon Wash, in southeastern Arizona. This map shows not only the arroyo channels and narrow flood plains that have developed since 1890, but also areas within a few miles of the wash that are severely gullied, severely sheet-eroded, and moderately sheet-eroded.

Two important effects of the third-largest recorded flood of the upper Gila River have been determined from the ERTS images -- the extent of inundation and the areas of severe sediment deposition and erosion -- even though the images were made a week and a half after the flood. The inundated area is best displayed on band 7 (as a belt distinctly darker than adjoining parts of the flood plain), and the areas of severe sand/gravel erosion/deposition show best on band 5 (as anomalously light-toned areas compared with earlier images).

Category designation symbols: A D, 3 G, H, I, 7 F.

- f. Published articles, etc. released during the reporting period: None.
- g. Recommendations: None.
- h. Changes in Standing Order Forms: None.
- i. ERTS Image Descriptor Forms: See following attachment.
- j. Data Request Forms submitted to GSFC/NDPF, by date:

January 17, 1973 (s)

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE 11/30/72

PRINCIPAL INVESTIGATOR R.B. Morrison

GSFC IN 050

ORGANIZATION U. S. Geological Survey

NDPF USE ONLY

D _____

R _____

ID _____

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Mountains	Desert	Cropland	
1029-17211-5-01	x	x	x	piedmont alluvial plains (bajadas), arroyos, Basin and Range topography, cities, flood plains, forest land, grassland, highway, clouds (scattered), dendritic drainage, axial streams, irrigation, lineaments, open pit mines, mine dumps, plateau, rangeland, rivers, riparian vegetation, valleys
1029-17213-5-01	x	x	x	alluvial flats (plains), arroyos, axial streams, bajadas (piedmont plains), cities, clouds (scattered), forest land, rangeland, grassland, highways, intermontane basin floors, Basin and Range topography, irrigation, lineaments, lava flow, mud flat, open pit mines, mine dumps, smelter, playas, rivers, riparian vegetation, valleys, volcanic field

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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301-982-5406

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PRINCIPAL INVESTIGATOR R. B. Morrison

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Mountains	Desert	Cropland	
1030-17271-5-01	x	x	x	alluvial plains, arroyos, axial streams, bajadas, (piedmont plains), Basin and Range topography, brushland, forest land, rangeland, grassland, dendritic drainage, erosion, flood plains, highways, intermontane basin floors, irrigation, lineaments, open pit mines, mine dumps, tailings ponds, playa and shore features, rivers, riparian vegetation, clouds (scattered), valleys, quarry
1065-17324-7-1	x	x	x	alluvial plains, arroyos, axial streams, bajadas (piedmont plains), brushland, forest land, range land, clouds (scattered), grassland, dendritic drainage, erosion, flood plains, highway, intermontane basin floors, irrigated farmland, lineaments, open pit mines, mine dumps, tailings ponds, playas, shorelines, rivers, riparian vegetation, valleys
1067-17324-7-1	x	x	x	Same as 1085-17330-5-01, except haze, smog.

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Mountains	Desert	Cropland	
1085-17330-5-01 do. -7-01	x	x	x	alluvial plains, bajadas (piedmont plains), pediments, arroyos, Basin and Range topography, cities, dams, erosion, flood plains, forest land, grassland, highway, irrigation, urban areas, metropolitan areas, lakes, reservoirs, rangeland, rivers, riparian vegetation, saline soil, valleys.
1085-17332-5-01	x	x	x	Adobe flats, alluvial flats (plains), arroyos, axial streams, bajadas (piedmont plains), city, Basin and Range topography, dunes, braided streams, flood plains, grassland, brushland, gulf, urban area, intermontane basin floor, irrigation, lineaments, open pit mines, mine dumps, mud flats, pediments, rangeland, rivers, riparian vegetation, saline soil, salt flat, spit, soils, suburban area, marsh (salt), tidal flat, valleys.

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Mountains	Desert	Cropland	
1101-17215-5-01	x	x	x	alluvial plain (flat), arroyos, axial streams, bajada (piedmont plain) Basin and Range topography, forest land, brushland, grassland, rangeland, den- dritic drainage, erosion, flood plains, highways, intermontane floors, irri- gation, lineaments, open pit mines, mine dumps, playas, rivers, riparian vegetation, mud flats, snow, towns, valleys.
1031-17325-5-01	x	x	x	same as 1085-17330-5,7-01 except has Newton rings
1065-17211-5-1	x	x	x	alluvial plains, arroyos, axial streams, bajadas (piedmont plains), Basin and Range topography, brushland, forest land, grassland, range land, clouds (scattered), cities, dendritic drainage, erosion, flood plains, intermontane basin floors, irrigation, lineaments, open pit mines, mine dumps, plateau, rivers, riparian vegetation, smelter smoke, valleys,

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15. Supplementary Notes			
<p>16. Abstracts</p> <p>We find that the "red" MSS band 5 gives the sharpest definition of modern arroyos. Of the best images, we can distinguish modern arroyos as narrow as 150 to 200 feet in reaches where their contrast with adjacent areas is only moderate, and as narrow as 60 to 75 feet where their contrast is high. Both the red and infrared bands show differences in soils and vegetation. In the late fall and winter imagery, band 7 generally is the most useful for mapping the areas of the more erodible soils.</p> <p>A map at 1:1 million scale has been prepared that shows all the arroyos within the 17,000-square-mile study area that have been identified from ERTS-1 images. Also, from U-2 color-infrared airphotos, a 1:125,000-scale map has been made of a 50-mile reach along San Simon Wash, in southeastern Arizona. This map shows not only the arroyo channels and narrow flood plains that have developed since 1890, but also areas within a few miles of the wash that are severely gullied, severely sheet-eroded, and moderately sheet-eroded.</p> <p>Two important effects of the third-largest recorded flood of the upper Gila River also have been determined from the ERTS images: the extent of inundation and the areas of severe sediment deposition and erosion—even though the images were made a week and a half after the flood. The inundated area is best displayed on band 7 (as a band distinctly darker than adjoining parts of the flood plain), and the areas of severe sand/gravel erosion/deposition show best on band 5 (as anomalously light-toned areas compared with earlier images).</p>			
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